lateral displacement of the projected point of light from the center of curvature of the spherical object. The size of the point image will also be a minimum size when the microscope is focused at the center of curvature.

[0009] A point source eyepiece is most likely to be used in a microscope system with a 10x to 40x microscope objective. The microscope may then be used to create a point source for a Star Test or to locate the center of curvature of an optical component. The point source created will, in general, be diffraction limited in size because the fiber point source will be reduced in size by the microscope magnification of perhaps 10 to 40x. Reflected light from a surface under test is visible in the eyepiece if the microscope is focused at or near the surface or center of curvature of the surface.

[0010] The fiber optic eyepiece as described is difficult to manufacture and fragile. Also, it is not convenient to couple in a variety of different light sources such as a halogen source or a laser diode. Additionally, the fiber itself obscures a portion of the field of view. Thus, what is needed is a robust device providing a point source and convenient viewing of a returned point source in a compact package that can be used for inspection of optical components and assemblies.

DISCLOSURE OF INVENTION

[0011] In accordance with the present invention, a point source module is provided, comprising:

[0012] (a) a Shack cube comprising a beam splitter cube having four optically functional faces, with an optical element having a spherical reference surface secured to one of the four faces and defining a reference arm;

[0013] (b) a test arm that is associated with transmission of optical radiation from a source to a sample and through one of the following:

[0014] (i) the reference surface, or

[0015] (ii) a face of the beam splitter cube adjacent the reference surface and on the opposite side of the beam splitting surface from the reference surface;

[0016] (c) a point source of optical radiation whose emissions are incident on a face of the beam splitter cube such that light from the source traverses both the reference arm and the test arm; and

[0017] (d) a detector associated with a face of the beam splitter cube adjacent the source and on the opposite side of the beam splitting surface from the source comprising a detector arm, an objective lens associated with the test arm, or both.

[0018] In a variant of the foregoing, an objective lens may be associated with the test arm to produce a point source microscope. In another variant of the foregoing an eyepiece may be installed in the detector arm producing a point source eyepiece for viewing by an eye acting as the detector.

[0019] In addition, a method of aligning the point source module is provided. The method comprises using a cat's eye type reflection associated with the objective lens so that images from the spherical reference surface and from the objective lens are coincident or separated, as desired.

[0020] Finally, a method of using a point source microscope (point source module plus objective lens) is provided. The method comprises obtaining information relating to optical datums, mechanical datums, or both.

[0021] The apparatus and method of the present invention provide a compact, robust device and technique for measuring or locating optical or mechanical datum of parts that are being manufactured or assembled.

BRIEF DESCRIPTION OF THE DRAWINGS

[0022] The drawings referred to in this description should be understood as not being drawn to scale except as specifically noted.

[0023] FIG. 1 is a prior art schematic diagram of an eyepiece with fiber source;

[0024] FIG. 2 is a prior art schematic diagram of a microscope;

[0025] FIGS. 3a-3b are each a schematic diagram of a point source microscope using a Shack cube, showing as the detector an eyepiece (FIG. 3a) or a CCD camera (FIG. 3b);

[0026] FIGS. 4a-4b are schematic diagrams showing the focus of a microscope objective at the center of curvature of a concave and convex spherical surface (FIG. 4a) or on a surface (FIG. 4b);

[0027] FIG. 5 is a schematic diagram of a point source microscope of the present invention using a modified Shack cube arrangement;

[0028] FIG. 6 is a schematic diagram of a phase shifting device employed in the point source microscope of the present invention and utilizing a translating prism; and

[0029] FIGS. 7a-7b are schematic diagrams of auxiliary lenses, where FIG. 7a depicts a finite conjugate relay lens and FIG. 7b depicts a collimator.

BEST MODES FOR CARRYING OUT THE INVENTION

[0030] Reference is now made in detail to a specific embodiment of the present invention, which illustrates the best mode presently contemplated by the inventors for practicing the invention. Alternative embodiments are also briefly described as applicable.

[0031] FIGS. 1 and 2 were briefly described above. In particular, FIG. 1 is a schematic diagram, in perspective, showing the combination of an eyepiece 10 and an optical fiber 12. The eyepiece 10 comprises an eyepiece tube 14, which includes an eyepiece lens 16 and an exit aperture 22. A point source 20 is the tip of optical fiber 12 and is placed in a reticle plane 18. As seen in FIG. 2, the reticle plane 18 is between the eyepiece lens 16 and an objective 26. Returning to FIG. 1, the exit aperture 22 is used for viewing by a person. The optical fiber 12 is seen to be operatively associated with the reticle plane 18.

[0032] FIG. 2 is a schematic diagram of a conventional microscope 22. The microscope 22 comprises a sample plane 24 for placing a sample, the objective 26, the reticle plane 18, and the eyepiece lens 16. The reference designation for the sample and the sample plane 24 are used interchangeably herein. The objective 26 focuses light to a focal point 25 on the sample plane 24.